

Appendix E Life Cycle Cost Methodology – Guidance

Purpose

Life Cycle Costing (LCC) is an important economic analysis used in the selection of alternatives that impact both pending and future costs. It compares initial investment options and identifies the least cost alternatives. LCC is referenced by several ESM Chapters including Ch 1 Section Z10 (design goals section) and Ch 14, Sustainable Design.

For utility decisions: At time of writing, FM-Utilities was not aware of any commercial/industrial demand-side management programs available from PNM, nor any no-cost design assistance provided by PNM.

Applications

Basic applications of LCC are addressed within the ESM and may be further defined within an AE's design programming scope requirements. It should be performed for new buildings and major renovations, and for new systems and equipment with a 20-year expected life. As applied to building design energy conservation measures, the process is mandated by law and is defined in the Code of Federal Regulations (CFR), Title 10, Part 436, Subpart A: *Program Rules of the Federal Energy Management Program*. In general, LCC is expected to support selection of all building systems that impact energy use: thermal envelope, passive solar features, fenestration, HVAC, domestic hot water, building automation and lighting. However, LCC can also be applied to building features or involve costs related to occupant productivity, system maintenance, environmental impact and any other issue that impacts costs over time. It is very important to recognize the significance of integrated building systems design in the overall efficiency of the design.

Methodology

There are many established guidelines and computer-based tools that effectively support Present Value LCC analyses. The National Institute of Standards and Technology (NIST) has prepared the Life Cycle Costing Manual for the Federal Energy Management Program ([NIST Handbook 135](#)), and annually issues real growth [Energy Price Indices and Discount Factors for LCC Analysis](#). As a companion product, NIST has also established the Building Life Cycle Cost (BLCC) computer program to perform LCC analyses. The latest versions of the BLCC program not only structure the analysis, but also includes current energy price indices and discount factor references. These NIST materials define all required LCC methodologies used in LANL design applications. It is recommended that the AE obtain the BLCC software and update from NIST. The latest information on NIST 135 and the BLCC software is available on the Internet at www.eere.energy.gov/femp (<http://www.eere.energy.gov/femp/program/lifecycle.cfm>) Discount rates to be used depend on whether the LCC analysis is for energy savings or general. Energy savings calculation discount rates are per the FEMP algorithm. General rates are given by OMB Circular A-94, App C. <http://www.whitehouse.gov/omb/circulars/a094/a094.html>

Procedures and Approach

The most effective approach to LCC is to appropriately integrate it into the design process.

The building design evolves from general concepts to detailed analysis. LCC needs to follow the same approach paralleling the focus to the current level of detail study.

It is extremely important for the effective development of the project that commitments are made and retained on the building systems, in a general sense, during the Conceptual Phase.

The building systems should be analyzed for appropriateness during the first stages of the Design Development Phase. A commitment on direction for the systems needs to be made at this time, and any further LCC studies focused on detail within each system.

All LCC efforts should be completed in the Design Development Phase of the project.

The following practices are typically required when conducting LCC analyses for building design. They are listed here to address common concerns and frequently asked questions.

1. When defining alternatives for LCC, an acceptable level of overall building services must be assured throughout the analysis period.
2. Design alternatives must be compared against a baseline reference alternate that is the lowest first cost of the alternatives being considered. The baseline alternate must offer a viable system, employing state-of-the-art design features, and be in compliance with all project requirements. Where existing conditions form part of the baseline alternate, the analysis must not only include intended project work, but also the additional costs necessary to achieve code compliance and reliable operation over the analysis period.
3. The analysis period should be chosen to fully represent all costs. When optimizing the design of a single system, all compared alternatives must be considered over the same analysis period. Where possible, the analysis period should be the smallest whole multiple of the service lives for the major systems involved in the analysis. Service lives of HVAC equipment can be found in the ASHRAE Applications manual's Owning and Operation Costs chapter.
4. Costs that have already been incurred or must be incurred, regardless of the chosen alternative, can be deemed "sunk" and excluded from the analysis. Costs that must be incurred during the period from design decisions to construction award should be deemed sunk.
5. Baseline and alternative first costs are typically those estimated for the construction award date. The LCC analysis can assume that the award date can be considered the zero point in time for the analysis period, with all other event times referenced to the construction award date. For greater simplicity, the year of design decision can also be considered as the zero point in time, and it can be assumed that the construction award will occur in that year.
6. Salvage values for alternatives are typically zero. However, in those cases where scrap values could impact decisions, the present value is calculated as its future value (scrap value) discounted back to the present from the year of occurrence. The formula for this is shown in the LCC Formulas Table Z10-E-1 below.

Table Z10-E-1 LCC Formulas			
Type of Cost	Cost Examples	Present Value Relationships	Comments
Sunk	<ul style="list-style-type: none"> • Design Fees • Funds irrevocably committed 	Not Applicable	Costs are not included in the Analysis.
First	<ul style="list-style-type: none"> • Investment Costs • Construction Costs • Purchase Price 	$PV = TV$	For those investment costs that begin at the start of the analysis period.
Salvage Value	<ul style="list-style-type: none"> • Scrap value of equipment at the end of its service life 	$PV = \frac{FV}{(1+d)^n}$ where $FV = TV(1+e)^n$	Present value equals the future value at the end of the service life, discounted by n service years.
Future Investment	<ul style="list-style-type: none"> • One time investments occurring after the start of the analysis period • Non-Annual maintenance or repair 	$PV = TV \frac{(1+e)^n}{(1+d)^n}$ Where FV is the time prorated amount that separates investment value to the end of service life salvage value.	Discount the future value (Today's Value escalated at rate e to year n) back to the present.

	<ul style="list-style-type: none"> Major alterations to initial investment work 		
Residual Value	<ul style="list-style-type: none"> Equipment with a service life extending beyond the analysis period 	$PV = \frac{FV}{(1+d)^n}$	Residual value equals the future value at the end of the analysis period, discounted to the present.
Annually Recurring Fixed	<ul style="list-style-type: none"> Fixed payment service contracts with inflation adjustments Preventative maintenance 	$PV = TV(UPW)$ <p>where</p> $UPW = \frac{(1+d)^n - 1}{d(1+d)^n}$	Annually Recurring Cost, relating to today's value, which increase in price at the same rate as general inflation. The UPW n factors are within the NIST BLCC program.
Annually Recurring Escalating	<ul style="list-style-type: none"> Service or maintenance which involve increasing amounts of work Frequent replacements that escalate at a rate different than inflation 	$PV = TV(UPW^*)$ <p>where</p> $UPW^* = \frac{\left[\frac{(1+e)^n}{(1+d)} \right] - 1}{1 - \frac{(1+d)}{(1+e)}}$ $or UPW^* = \left(\frac{1+e}{d-e} \right) \cdot \left[1 - \left(\frac{1+e}{1+d} \right)^n \right]$	The present value of such costs are calculated by using a modified version of the UPW formula (UPW*) which allows for cost escalation.
Energy	<ul style="list-style-type: none"> Fuel related costs, such as fuel oil, natural gas or electricity 	$PV = TV(UPW^*)$	Energy related UPW* factors are found in the NIST BLCC program.
Escalation Rates	<ul style="list-style-type: none"> Relating Budgetary Escalation to Real Growth Escalation 	$E = e + I + eI$ <p>or $e = \frac{E-I}{1+I}$</p>	Needed to convert budgetary escalation to real growth escalation.
<p>Definitions</p> <p>FV = future value</p> <p>PV = present value</p> <p>TV = today's value</p> <p>d = real discount rate</p> <p>e = real growth escalation rate (the differential escalation rate that exists after removing the influence of general inflation)</p> <p>n = number of years to occurrence or the analysis period, as appropriate</p> <p>E = Budgetary Escalation</p> <p>I = Inflation Rate</p> <p>UPW = Uniform Present Worth factor for fixed recurring costs</p> <p>UPW* = Modified Uniform Present Worth factor for escalating recurring costs</p>			

- Future one-time costs, such as replacement costs, are established by escalating a known today's value (using real growth rate) to its future value in the year it occurs, then discounting that value back to its present value (using a real discount rate). The formula for this is shown in the LCC Formulas Table above.
- For instances where an alternative has service life beyond the analysis period, allowance shall be made for the associated residual service worth. This calculation involves identifying the future residual

value at the end of the analysis period, then discounting the amount back to the present. The future residual value can be approximated by multiplying the future investment value (less future salvage value at the end of its service life) by the proportion of time remaining in the analysis period, compared to its service life.

9. Annually recurring fixed costs include those costs where increases have no real growth, such as costs that increase at the general inflation rate. They can be represented by the formula shown in the LCC Formulas Table above. Also in this table is the formula for recurring costs where recurring costs escalate. Both formulas involve multiplying a known cost (in today's value) by a uniform present worth value.
10. Fuel costs represent a special case of recurring escalating costs. Uniform present worth values are available from NIST data, correlating specific fuel types by sector/location for a defined analysis period. For simplicity, demand charges may be assumed to escalate at the same rate as consumption charges.
11. Investment and replacement actions over time may impact recurring costs. For simplicity, unless otherwise directed, fluctuating recurring cost savings may be assumed to be proportionate to the savings realized at the start of the analysis period.
12. Calculate the savings-to-investment ratio (SIR) for comparisons of dissimilar alternatives, such as comparing an HVAC alternative to a lighting alternative. Calculate net savings for comparisons of similar alternatives, such as optimizing insulation thickness in a wall.
13. A sensitivity analysis is required whenever assumptions may be considered questionable. This simply requires conducting multiple LCC analyses using extremes of cost parameters in question.
14. Due to possible margins of error in estimating costs, alternatives with an LCC differential of less than 10 percent can be judged inconclusive.
15. To define energy related cost impacts for alternatives that are influenced by weather and/or varying loads/schedules, the energy use modeling program DOE-2 or other approved software shall be used.

Endnotes/Bases

Material adapted from GSA's *Facilities Standards for the Public Buildings Service*, PBS-P100, March 2005, Section 1.8